Organoleptic Properties of Foam Spray-Dried Products Made from Deodorized Milk Fat and Skimmilk

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Abstract

Powders made by foam spray drying mixtures of deodorized milk fat and skimmilk were reconstituted to beverages having a flavor similar to fresh whole milk. When packed in oxygen-free atmosphere of nitrogen, only a slight decline in flavor score was noted during storage for six months at 4 and 27 C. Highest initial flavor score and best storage stability were obtained when continuously made milk fat was deodorized and recombined with the skimmilk without exposure to air prior to condensing and drying with ozone-free air.

Introduction

Improvements in drying and packaging technology (5, 10) have made it possible to manufacture a spray-dried whole milk which, initially, can be reconstituted to a beverage with a flavor quality equal to that of fresh milk and which can be stored for six months or more without oxidative deterioration. During storage, however, nonoxidative changes produce compounds which, if in sufficiently high concentration, are detectable as off flavors.

Extensive research by Patton and co-workers (e.g., 3, 12, 13) established the great importance of lactones in nonoxidative off flavors and led to the issuance of a patent (7) for stabilizing the flavor of milk fat by steam deodorization. The role of ketones, as well as of lactones, in the development of off flavors in milk fat has been reviewed by Kinsella et al. (4).

Since our own research failed to discover production methods by which low-heat pasteurized whole milk could be dried to a form in which lactone formation was adequately controlled during storage at elevated temperatures (which increase their rate of formation), we undertook a study of the properties of foam spray-dried products made from mixtures of slightly modified milk components.

This paper describes techniques to make beverage milk-type powders from a mixture of deodorized milk fat and skimmilk. The organoleptic properties of these materials reconstituted fresh and after storage at different temperatures are also presented with data showing the flavor improvement achieved with improved techniques.

Materials and Methods

Two types of milk fat were manufactured for recombination with skimmilk before drying. The first was made by the classic method of melting sweet cream butter and isolating the fat with a conventional cream separator, as previously described (8). The second type was made from pasteurized cream, using a "clarifixator" phase inverter and centrifuges assembled in line, as described by Fjaervoll (1). The heat treatment of fat during isolation by this method was: a) 30 minutes at 65 to 77 C, b) 6.5 minutes at 77 to 85 C, c) 7.5 minutes at 85 C and d) 7.5 minutes at 85 to 63 C.

Portions of both types of milk fat were packed for storage in no. 1 tin cans and held open for 18 hours at 43 C and 1 mm pressure before filling with nitrogen (ultrahigh purity grade, $< 0.0015\%$ O_2) (8, 11) to a pressure of 1.5 atm and sealing.

Other portions were steam deodorized in a pilot scale deodorizer built from a 30-liter, stainless steel, single effect evaporating pan. General dimensions and provisions for heating, cooling, vacuum pumping, steam injection, temperature measurements, and fat observation are shown in Figure 1. The milk fat prepared from melted butter was deodorized in 12-liter batches held for five hours at 145 C and 1 mm pressure with an average steam flow equivalent to 290 g of water per hour. The continuously made milk fat was deodorized in 14-liter batches, held for six hours at 150 C and 2 mm pressure with an average steam flow equivalent to 280 g of water per hour. In all instances, after deodorization, the products were cooled and the vacuum broken with nitrogen. Portions of the deodorized fats were packed as described

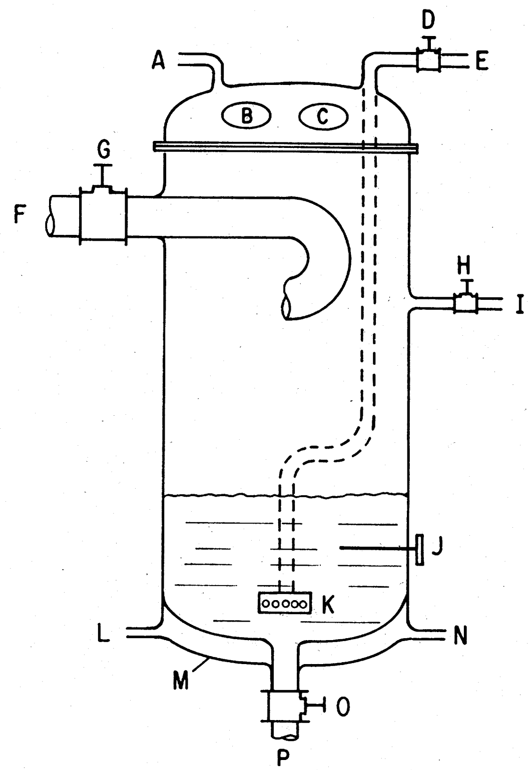

FIG. 1. Apparatus for deodorizing milk fat. A, to manometer; B, window for illumination; C, window for observation; D, needle valve for controlling steam flow; E, to steam generator; F, to vacuum; G, valve; H, needle valve to control addition of nitrogen; I, to nitrogen tank; J, dial thermometer; K, multi-opening sparger; L, to pressurized steam; M, steam jacket; N, to steam condenser; O, valve; P, to fat metering pump.

for nondeodorized fat and stored. Other portions were used to prepare dried products.

According to the fat used, three types of powder were prepared by mixing the fat with skimmilk and foam spray drying: a) deodorized milk fat made from melted butter, b) the same fat without deodorization, and c) deodorized milk fat made with a "clarifixator" phase inverter. A fourth type of powder was made by foam spray drying whole milk directly, without the intermediate steps of isolating the milk fat and recombining it with skimmilk.

For preparing the first two types of powder, skimmilk pasteurized for 30 seconds at 77 C, was concentrated in a falling film evaporator to 42% total solids. Proportions of this concentrate and milk fat characteristic of whole milk were mixed in a vat by hand stirring, and the mixture homogenized twice at 63 C by passage through a Manton-Gaulin Model[1] 15-KF 3-8 BS homogenizer. On the first pass a pressure of 70.3 kg/cm^2 was used in the first stage only. The second pass applied 281.2 and 35.2 kg/cm^2 pressure to the first and second stage. These homogenized mixtures were foam spray-dried by injecting pressurized nitrogen into the concentrate at a point between the pressure pump and the spray nozzle, using equipment and general procedures previously described (2).

In preparing the third type of powder, the deodorized milk fat was recombined with skimmilk without any air exposure after deodorization. In this operation, a feed line was connected from the deodorizer through a Millroy positive displacement metering pump to the skimmilk line at a point just before the Mallory heater. The deodorized fat, in an atmosphere of nitrogen, was metered under pressure into the skimmilk at a rate which gave a fat-skimmilk ratio characteristic of whole milk. This mixture was pasteurized in the Mallory heater at 77 C for 30 seconds. The pasteurized mixture was fed continuously through a single stage homogenizing valve at 175.8 kg/cm^2 before entering a falling film evaporator wherein it was concentrated to 45% total solids.

The powder from this concentrate and the one prepared directly from whole milk were foam spray-dried as previously described (2), but with charcoal filters at the dryer air inlet for removing ozone and with liquid nitrogen for cooling the powder before collection (5).

All powders were packed in tins containing an oxygen-scavenging system (95% nitrogen, 5% hydrogen, Pt catalyst) which quickly reduces residual in-pack oxygen to water (10). Powders were stored at −18, 4, and 27 C as indicated in the figures and tables. Powders to be stored at −18 C, where the catalyst is ineffective, were first stored for one month at 4 C.

For flavor evaluations, the powders were reconstituted with water and judged as whole milks by a 10-man trained panel using a modified ADSA scoring system with a range of 31 to 40 (6, 11). All samples were tasted blind, in duplicate, with no more than 10 samples (including duplicates) presented at one time.

For comparisons, samples of each milk fat stored at the same temperatures were evaluated for flavor after recombining with sufficient skimmilk to give beverages of 3.3% fat (8).

[1] Mention of brand or firm names does not constitute an endorsement by the Department of Agriculture over others of a similar nature not mentioned.

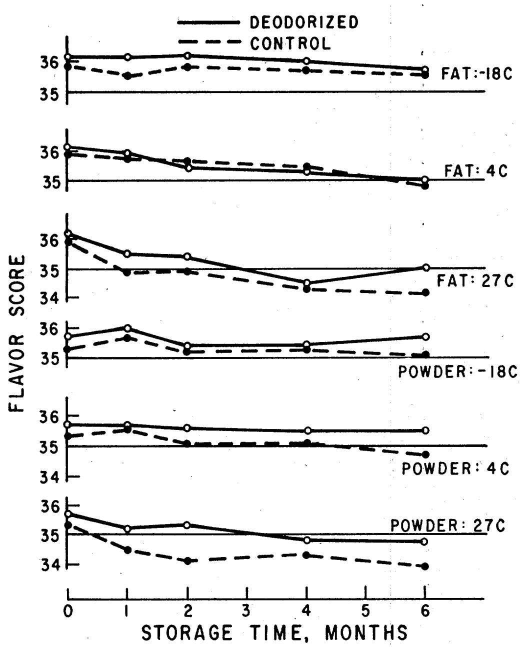

FIG. 2. Effect of steam deodorization on the flavor quality and storage stability of products prepared with older techniques. Data averaged from three experiments.

Results

The flavor scores of products made from milk fat obtained by melting butter and handling it with simple equipment and change of scores during storage are shown in Figure 2. In all instances there was some loss of flavor from that of fresh milk which, by our taste panel, averaged about 37 in score. It can be seen from the upper part of the figure that the process of making milk fat and recombining it with skimmilk results in some loss of flavor and, from the lower part of the figure, a further loss of quality in drying the recombined milk. Deodorizing the fat before recombining somewhat improves the recombined product which is retained during drying. During storage the rate of flavor loss is dependent upon temperature. No significant change can be observed in the powders during six months of storage at −18 C. At the highest temperature, 27 C, the stabilizing effect of deodorization is apparent. However, because of its relatively low initial score, during storage at 27 C the product with deodorized fat dropped to borderline acceptability—a score of about 35.

Improvement in flavor quality can be obtained by utilizing more sophisticated techniques during processing. The extent of this improvement is evident from data in Figure 3 and by comparing these data with those in Figure 2. Fat made from cream continuously with a phase inverter can be deodorized, recombined with skimmilk, and dried to a powder having the same organoleptic properties as foam spray-dried whole milk—the flavor of each product being equal to that of fresh milk.

The data of Figure 3 show that the storage stability of deodorized milk fat, whether stored separately or incorporated into a whole milk-type powder, is much superior to that of the nondeodorized fat. By comparing nondeodorized products stored at 4 C with deodorized products stored at 27 C, it can be seen that deodorized milk fat in product manufacture is superior to conventional refrigeration in maintaining product quality.

Data in Figures 2 and 3 show that flavor decline of various powders during storage approximately parallels changes in the stored fat samples. Steam deodorization effects stabilization primarily by reduction of the lactone flavor, as shown by subjective responses of judges listed in Tables 1 and 2.

Discussion

Our results indicate that high-grade deodorized milk fat can be mixed with skimmilk,

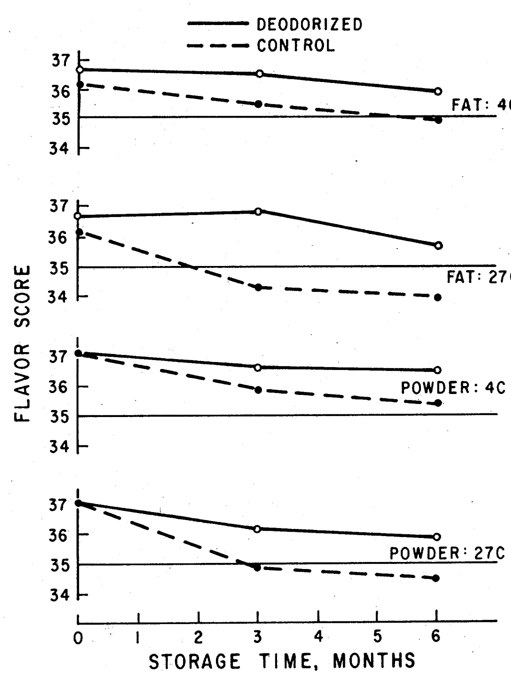

FIG. 3. Effect of steam deodorization on the flavor quality and storage stability of products prepared with newer techniques. Data averaged from two experiments.

TABLE 1. Effect of steam deodorization upon the number of stale and lactone criticisms of products prepared with older techniques.

	Initially[a]		During storage[a,b]					
			−18 C		4 C		27 C	
	Stale	Lactone	Stale	Lactone	Stale	Lactone	Stale	Lactone
Control fat	3	1	4.0	0.5	4.0	1.5	3.8	3.8
Deodorized fat	2	0	4.0	0.0	4.0	0.0	3.0	0.0
Control dried product	7	0	5.3	0.5	5.5	1.5	4.3	3.5
Dried product with deodorized fat	4	0	5.0	0.0	5.5	0.3	4.8	0.0

[a] Number of criticisms are those per ten flavor judgments.
[b] Data averaged from three experiments for 1, 2, 4 and 6 months storage.

pasteurized, condensed, and dried to a powder which, when reconstituted while fresh, has the same flavor as high quality foam spray-dried whole milk. Both products were scored equal to fresh market milk. Our success with these products, relative to the lower scoring products prepared with older techniques, appears to result from technical improvements in processing which a) minimizes air exposure during preparation of milk fat, b) excludes air from deodorized fat before and during mixing with skimmilk (except for that air dissolved in the skimmilk which is almost immediately removed in the evaporator), and c) excludes ozone during drying.

During storage of these products at 4 and 27 C, the deodorized fat-containing material loses some flavor quality, but much less rapidly than the nondeodorized product. The stabilizing effect of deodorization allows production of powders that keep better at 27 C than does foam spray-dried whole milk at 4 C. Since the deodorized fat-containing product can be made to have high initial flavor and flavor deterioration is slow, it can be considered to be capable of maintaining consumer acceptability during six months of handling and storage at room temperature.

The cost of producing stable milk-like powders has not been determined. However, it can be inferred from known costs of anhydrous milk fat manufacture and steam deodorization of vegetable oils that the added expense should not be substantially greater than that for continuous refregeration of whole milk powder during wholesaling and retailing.

Some question may arise as to whether ultimate flavor stability could be achieved by more extensive steam deodorization of fat during processing. This is impractical, since previous work (9) has demonstrated that some of the volatiles in milk fat are necessary to maintain its unique flavor and the addition of intensively deodorized milk fat to skimmilk does not improve its flavor.

During this presentation of our work we have deliberately refrained from calling our flavor-stabilized powders dry whole milk since they

TABLE 2. Effect of steam deodorization upon the number of stale and lactone criticisms of products prepared with newer techniques.

	Initially[a]		During storage[a,b]			
			4 C		27 C	
	Stale	Lactone	Stale	Lactone	Stale	Lactone
Control fat	1.5	1.3	0.9	6.3	0.7	7.4
Deodorized fat	0.0	0.5	2.2	0.5	2.3	1.0
Control dried product	0.5	0.0	0.5	6.2	0.7	7.8
Dried product with deodorized fat	0.8	0.5	2.3	0.0	1.7	2.6

[a] Number of criticisms are those per ten flavor judgments.
[b] Data averaged from two experiments for three and six months storage.

contain neither the fat globule membrane fraction nor the lactone precursor fractions of milk. If produced for commerce, a consideration of proper labeling would be required.

Acknowledgment

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